Increasing Regulatory Acceptance of Passive Samplers

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14. ABSTRACT

Laboratory and limited field testing of several types of passive samplers have shown that these tools can be used to measure pore water concentrations and to better understand contaminant bioavailability and the bioaccumulation potential of contaminants associated with sediment. This talk will briefly describe the types of passive samplers, their uses, and their advantages and disadvantages. Current limitations and concerns on reliability and accuracy will be discussed. Ideas for increasing their use in a regulatory environment for site characterization and remedy evaluation at Superfund sites will be presented.

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INCREASING REGULATORY ACCEPTANCE OF PASSIVE SAMPLERS

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Laboratory and limited field testing of several types of passive samplers have shown that these tools can be used to measure pore water concentrations and to better understand contaminant bioavailability and the bioaccumulation potential of contaminants associated with sediment. This talk will briefly describe the types of passive samplers, their uses, and their advantages and disadvantages. Current limitations and concerns on reliability and accuracy will be discussed. Ideas for increasing their use in a regulatory environment for site characterization and remedy evaluation at Superfund sites will be presented.

Key Questions

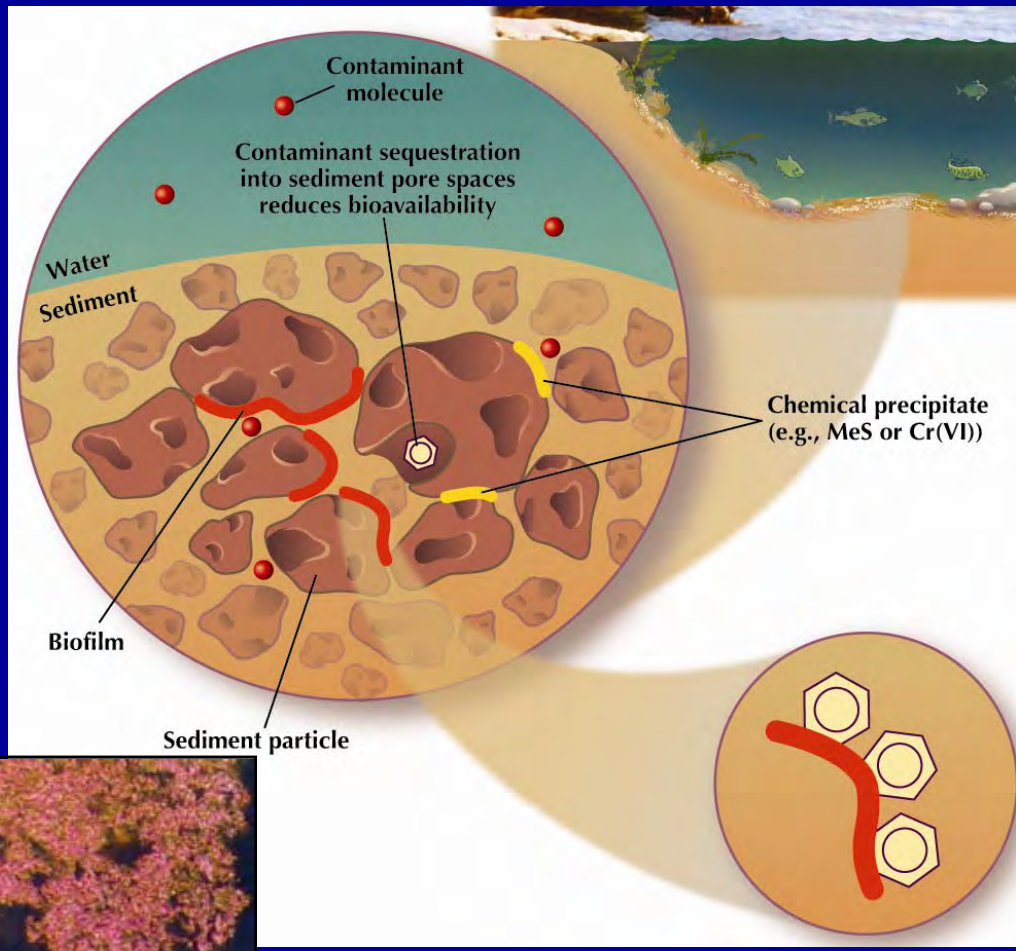
- Are they “better”; cheaper or quicker?
- Are they more than tools for just understanding the conceptual site model (CSM), or can results be used for remedy decision making?
- What are the uncertainties?
- Are they user friendly enough?
- What are the barriers to increased use?
- What are the next steps, for researchers, EPA and users?

Regulatory “Acceptance”

- They are accepted
- Are being used at several sites, mostly to revise the Conceptual Site Model and measure water column
- Is no formal Superfund acceptance process
- If passive samplers helps remedial project managers (RPMs) answer key site questions, they will be used:
  - Is there a risk, what are the key exposure pathways?
  - What combination of dredging, capping, MNR?
  - What are the risk-based goals and sediment cleanup levels?
  - How to determine remedy effectiveness?
  - Does the remedy meet AWQC?

Need for Passive Samplers

- Sediments and organic carbon aren't created equal
- They vary in potential to drive contaminant bioavailability and uptake



charcoal

coke

soot carbon

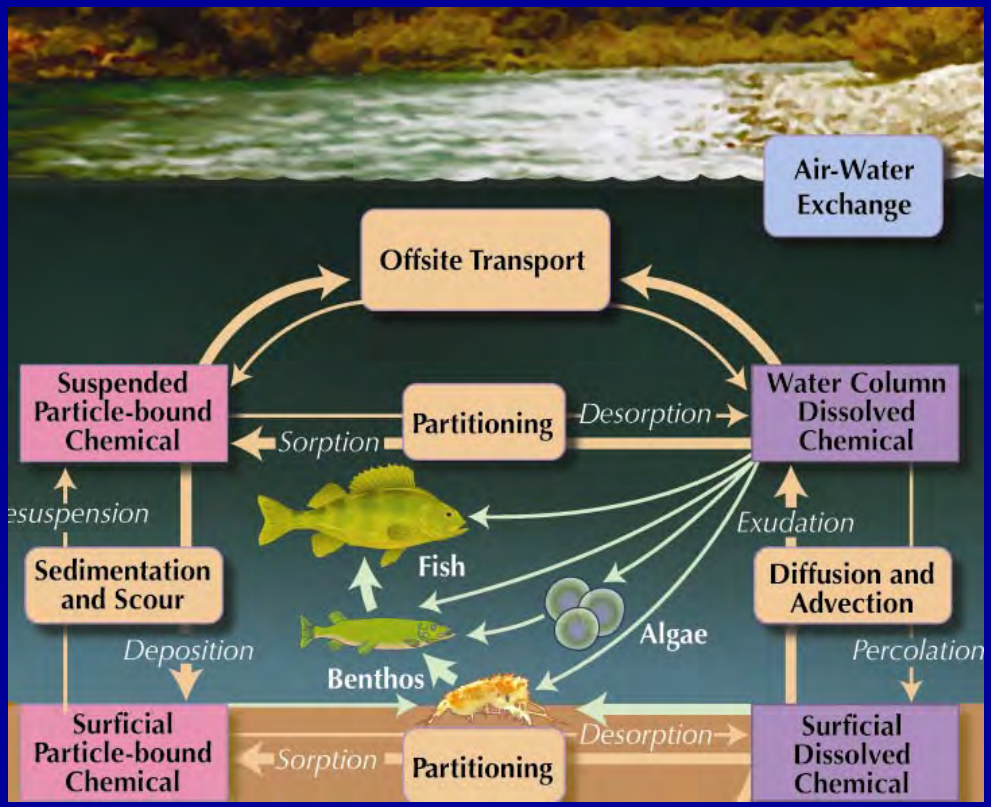
(Ghosh 2003)

(Magar et al. 2009)

Need for Passive Samplers

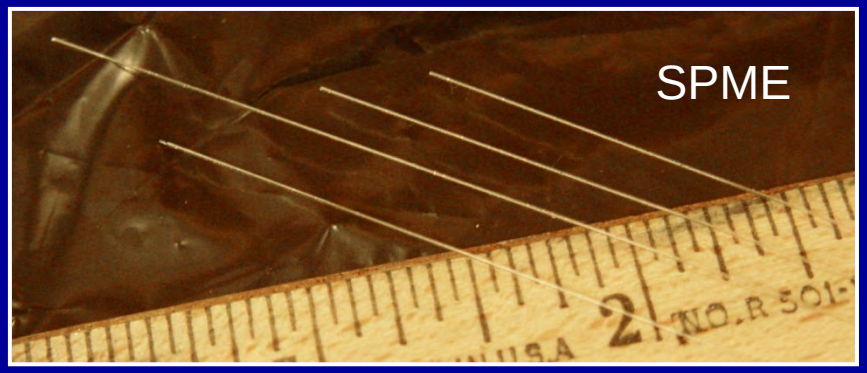
- We need better tools to translate the relationship between sediments and organisms

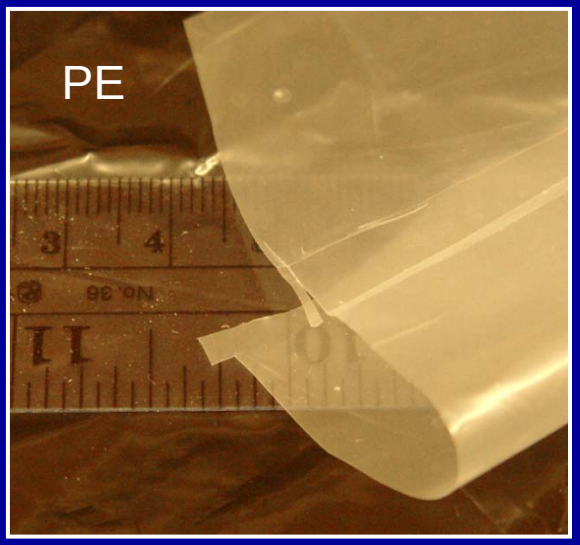
- Need to know “freely-dissolved” concentration that is bioavailable



(Magar et al. 2009)

Types of Passive Samplers

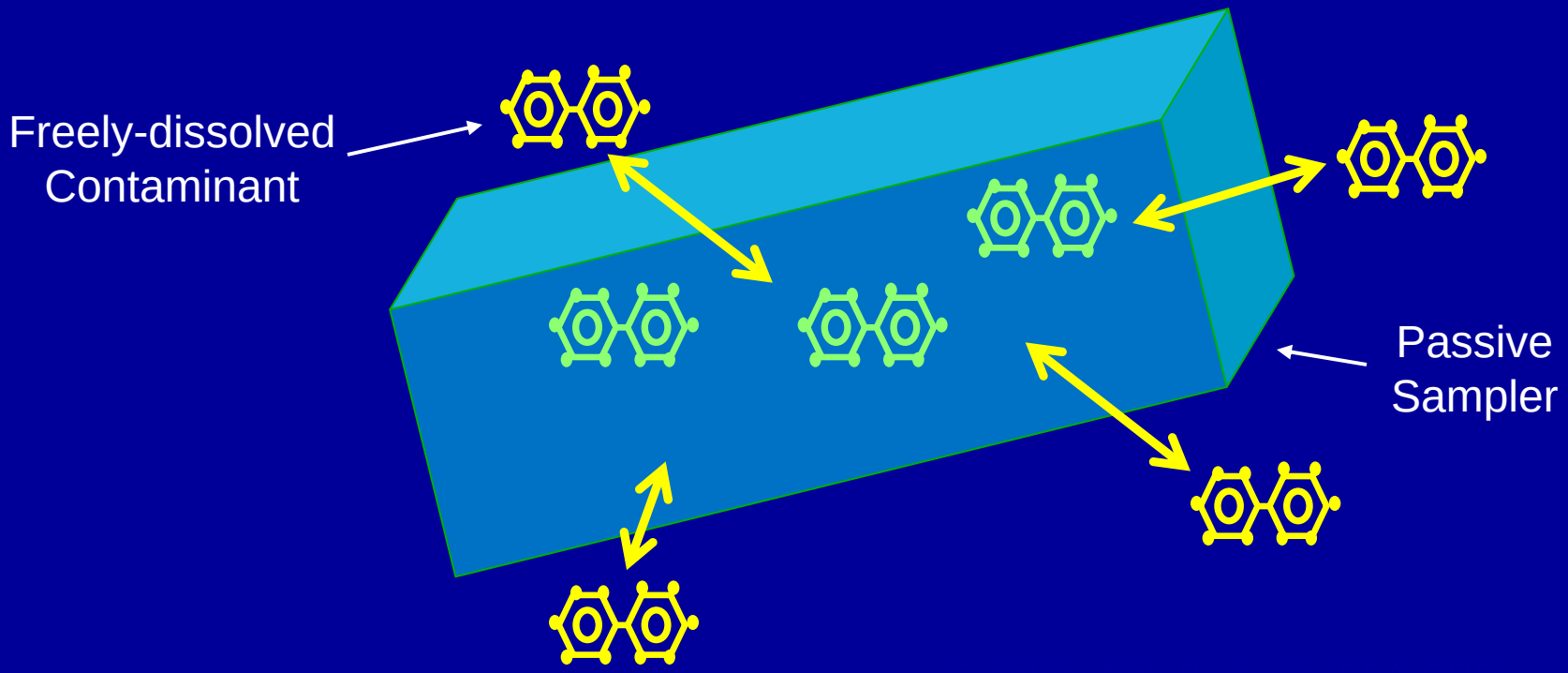




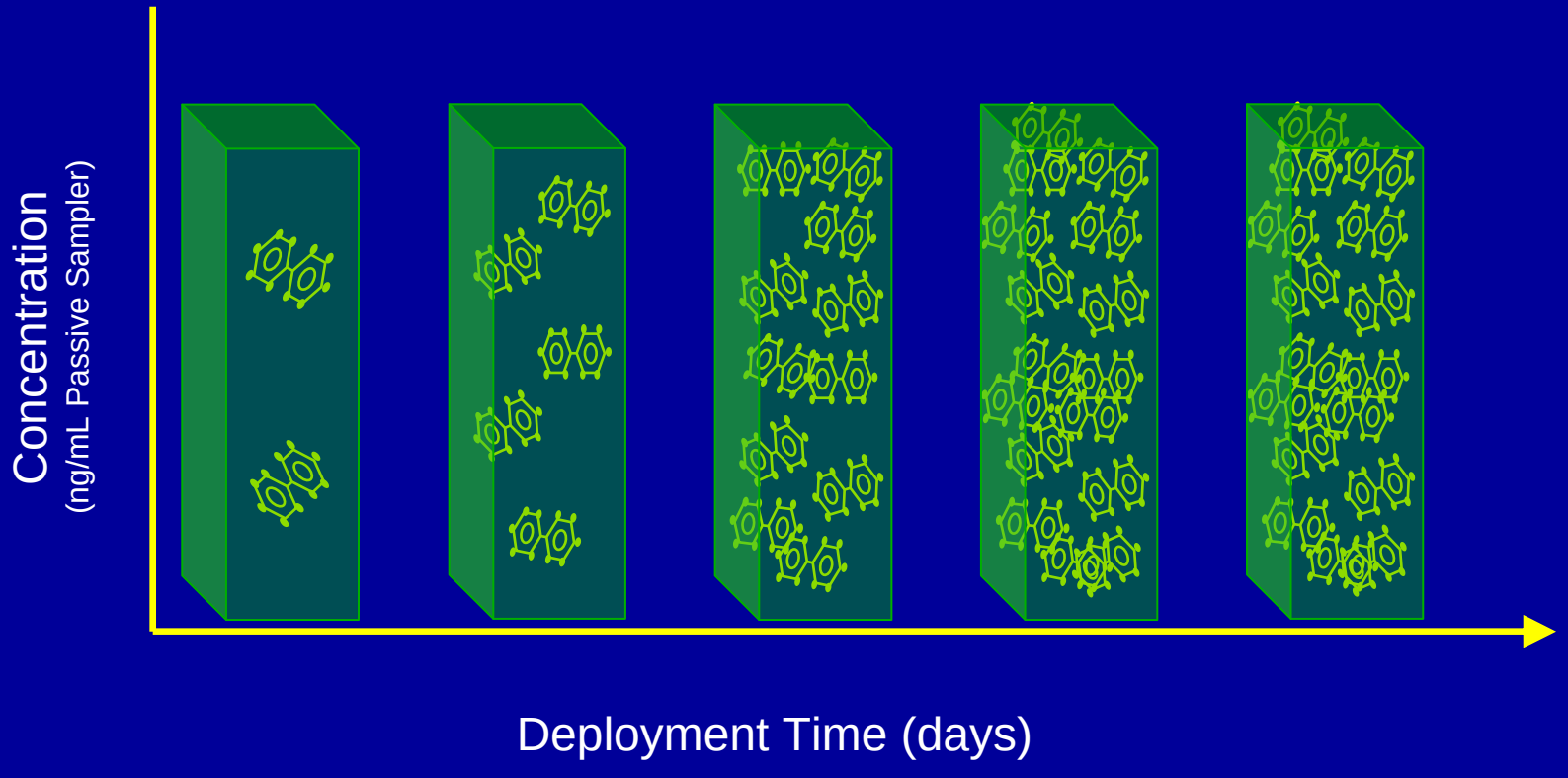
- Commonly used passive samplers in North America:
  - Polyethylene (PE)
  - Polyoxymethylene (POM)
  - Solid phase microextraction (SPME)

Passive Samplers

- Accumulate freely-dissolved organic contaminants from surrounding water into a solid phase
- Contaminant concentrations of the samplers are measured
- Passive sampler-based dissolved concentrations are comparable to carefully measured conventional dissolved water concentrations



Prediction of Dissolved and Bioavailable Concentration

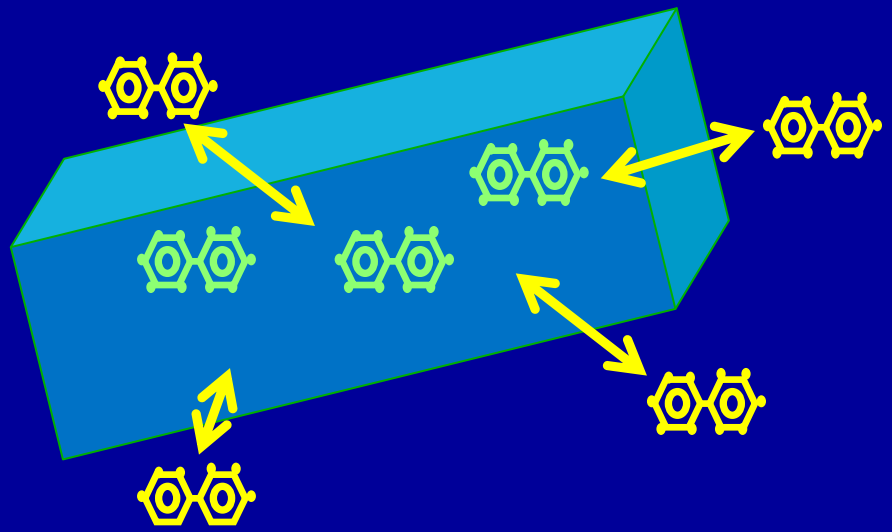


"Equilibrium" Sampling

Prediction of Dissolved and Bioavailable Concentration

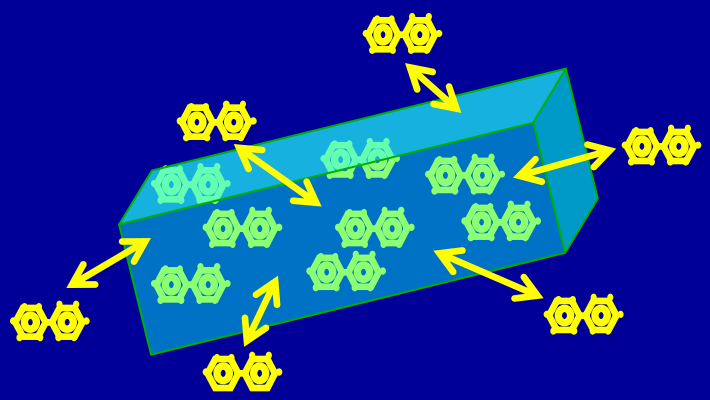
• Using basic analytical measurements and information, the dissolved and bioavailable concentration can be calculated:

$$\text{Dissolved Contaminant Concentration} = \frac{\text{Passive Sampler Contaminant Concentration}}{\text{Partition Coefficient}}$$



Scenario #1

Water Quality Criteria < Dissolved Contaminant Concentration = Passive Sampler Contaminant Concentration / Partition Coefficient



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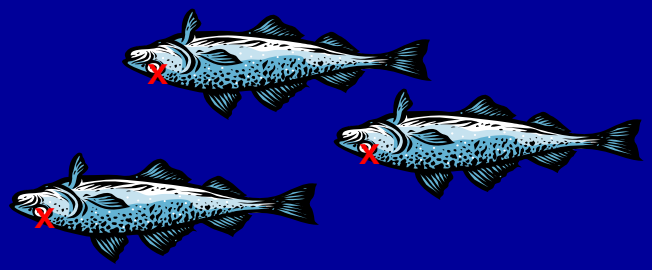
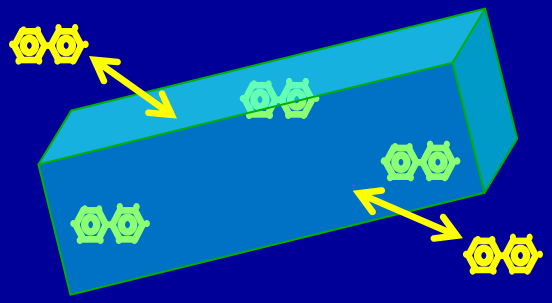


Scenario #2

Water Quality Criteria > Dissolved Contaminant Concentration = Passive Sampler Contaminant Concentration / Partition Coefficient



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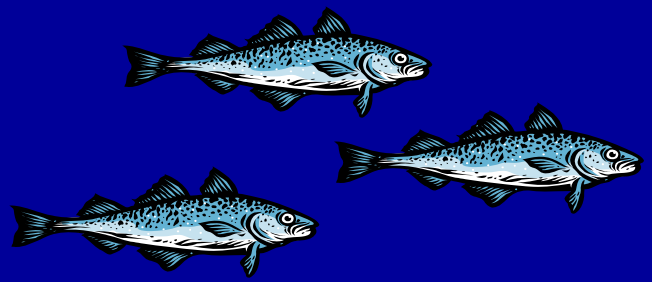


Important Regulatory Information from Passive Samplers

(1) Dissolved and Bioavailable Concentrations

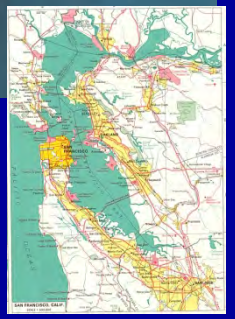
- Water column and pore waters
- Compare to regulatory guidelines
  - e.g., Water Quality Criteria

(2) Passive Sampler Concentrations

- Emulate uptake by some aquatic organisms
  - Biomonitoring organisms (e.g., blue mussels)
- May serve as surrogate when biomonitoring organisms are unavailable or cannot be used

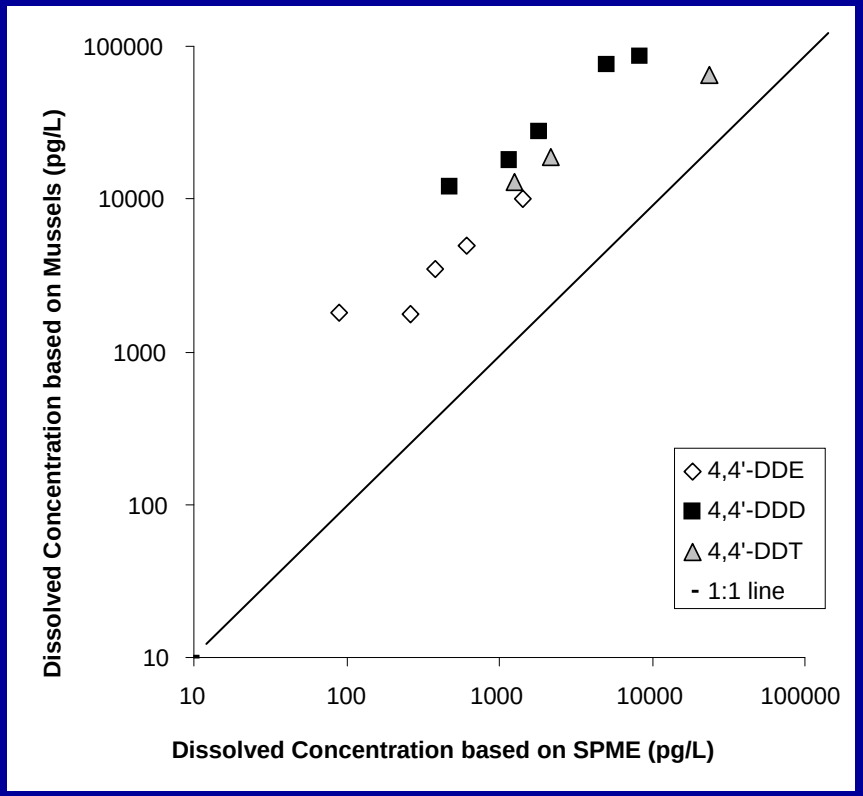
Regulatory Examples using Passive Samplers at Superfund Sites

- United Heckathorn Superfund site (CA)
- Regulatory Objectives
  - Use passive samplers to monitor water column concentrations before, during and after remediation
    - Measure dissolved contaminant concentrations using water column deployed samplers
    - Determine if Water Quality Criteria are being exceeded (i.e., DDTs & Dieldrin)



Regulatory Examples using Passive Samplers at Superfund Sites

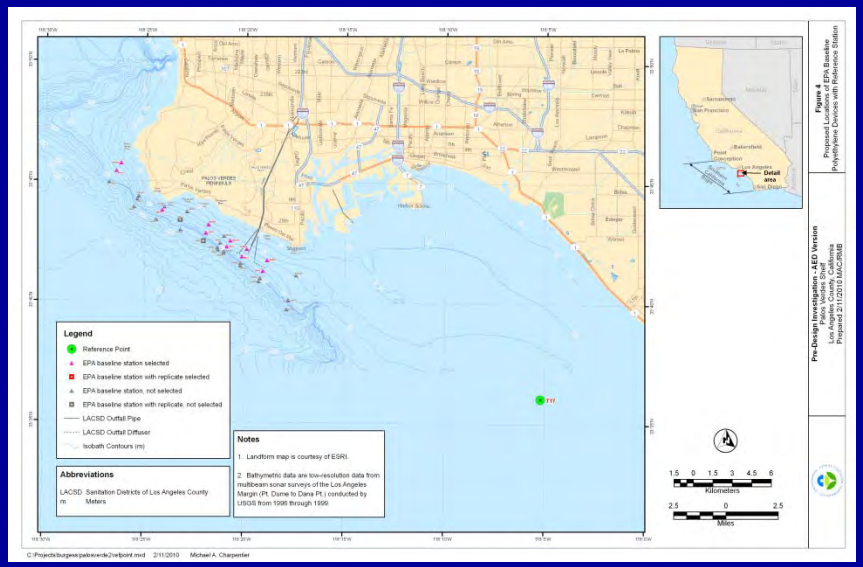
- United Heckathorn Superfund site (CA) (continued)
- Regulatory Objectives
  - Identify locations of contaminant sources to the water column by placing samplers at the sediment-water interface
  - Compare uptake of contaminants by passive samplers to mussel bioaccumulation via co-deployment



(Gschwend et al. 2010)

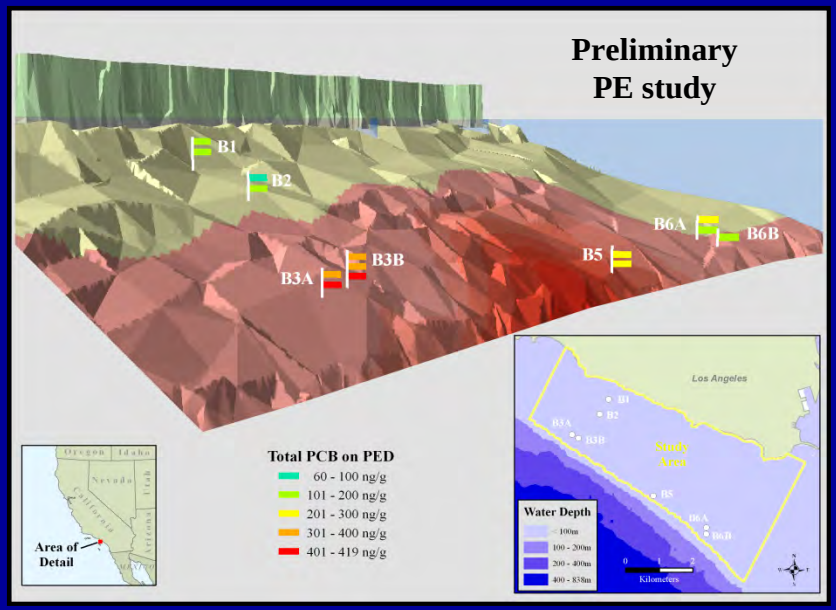
More Regulatory Examples

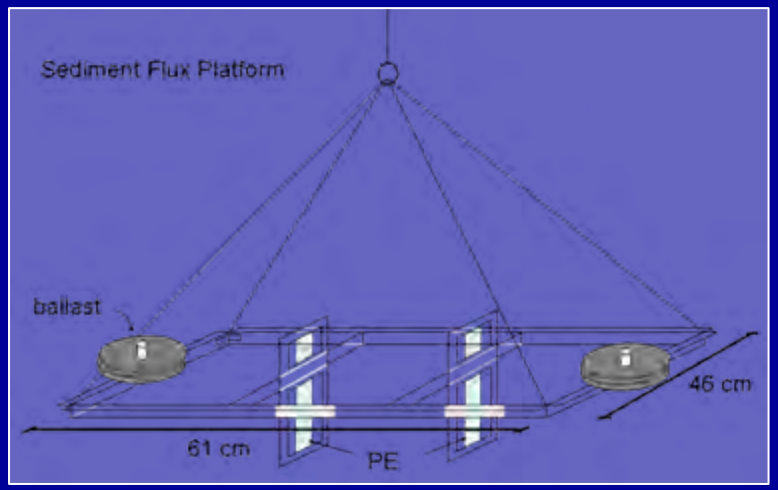
- Palos Verdes Shelf Superfund site (CA)
- Regulatory Objectives
  - Use passive samplers to monitor water column concentrations before, during and after remediation
    - Measure dissolved contaminant concentrations using water column deployed samplers
    - Determine if Water Quality Criteria are being exceeded (i.e., DDTs & PCBs)



More Regulatory Examples

- Palos Verdes Shelf Superfund site (CA) (Cont.)
- Regulatory Objectives
  - Assess flux of contaminants from sediment into water column
    - Determine remediation effectiveness by placing samplers at the sediment-water interface





(Fernandez et al. 2010)

More Regulatory Examples

- Using Passive Samplers to Evaluate Remedial Caps
  - Use below cap surface, near cap surface, and in surface water just above cap
  - Measure changes in porewater over time at depth, measure contaminant flux thru cap
- Capping Sites
  - McCormick and Baxter (OR)
  - Pacific Sound Resources (WA)
  - Chattanooga Creek (TN)

Advantages of Passive Samplers

- Less interference from particles, colloids and dissolved organic matter compared to traditional analyses
- Lower cost of sampling and analysis vs. traditional large volumes of water (or porewater)
- Higher rate of recovery vs. caged biota
- Cleaner analytical sample matrix vs. traditional types of samples
- Potential for at least an order of magnitude improved detection limit vs. large volume analysis
- Integrated measure over period of deployment time vs. less reliable snap shot
- Generate data on the bioavailable concentrations of contaminants

Limitations

- Currently, few validation studies
- Requires extended deployments of many days to achieve equilibrium depending on the contaminant
- Need to correct for longer equilibrium times
- Process for correction not simple
  - Availability of “right” partition coefficients
  - Analysis and interpretation of performance reference compounds

Barriers to Use

- Currently perceived as less certain, more difficult to use and interpret than traditional water analyses
  - even though traditional analyses are not “easy” to do right
- Plenty of scientific literature on passive samplers but little technical guidance documentation
- Dissolved concentrations are predicted rather than determined empirically
- When principle responsible parties (PRPs) want to use passive samplers, a perceived bias exists that higher bulk sediment cleanup number will result

Potential Next Steps

- More field use by non-researchers (e.g., RPMs), expand group of practitioners and reduce negative perceptions
  - Increase user-friendliness
- Report results in forums suitable for RPMs
- Develop an EPA fact sheet on their general use and interpretation
- Have independent body evaluate their use, accuracy, and reliability
- Holy Grail – Superfund Directive on using passive sampler-derived concentrations to evaluate risks and select cleanup levels

Thanks to My Coauthors!

- Dr. Robert M. Burgess, EPA, ORD-NHERL Narragansett, RI
- Dr. Karl Gustavson, USACE, ERDC, Washington, DC